Emittance Reduction by Adding One Strong Wiggler in the APS Storage Ring.

L. Emery

This describes the possible benefits of having a strong damping wiggler in one section of the SR.

The emittance is inversely proportional to the damping rate. The damping rate is proportional to the energy radiated in one turn. The emittances reported for various lattices at APS do not necessarily take credit for the additional damping from undulator closed to various gaps. In actual APS operation when the gaps are closed to whatever the User settings are, the radiation loss per turn and the damping increases by about 10%.

If one inserted a very strong wiggler in the storage ring as an additional radiator, the potential decrease in emittance could be a few tens of percent.

It is easier to discuss this in terms relative to the main dipole magnets, and use the radiation power from all dipole as the baseline damping rate. There are 80 dipoles with length 3.06 m and field 0.60 T. The radiation power for all dipoles goes as $N_{dip}\ L_{dip}\ E^2\ B^2$. We skip over the details of physical constants here since we are discussing a relative change to the damping. The E^2 term doesn't need to be considered either since it is a constant for the beam. For an APS dipole, $L_{dip}\ B^2 = 1.1\ T^2$-m. As an instructive aside, if we changed the length and strength of the dipole while keeping $L_{dip}\ B$ (i.e. the bend angle) the same, then the radiation power will be affected. For example, halving the dipoles will double the radiation power, and double the damping,i.e. $(L_{dip}/2)\ (2B)^2 = 2\ L_{dip}\ B^2$. We are not advocating this method to increase damping at the APS because the presence of dispersion in the dipoles will increase the quantum excitation term for the dipole by a factor of about 4, which will spoil the resulting emittance.

A wiggler placed in a zero-dispersion straight section can give the damping equivalent of several dipoles, but without the quantum excitation. Take for example, a 2 T wiggler magnet 5 m long. The integral of B^2 is 10 T^2-m, which is about 9 times the values for a single dipole. In order to make this wiggler produce little quantum excitation, the straight section should have zero dispersion. Also the period length should be reasonably small, in order to avoid large internal dispersion function.

Inserting this wiggler will reduce the emittance of any lattice by a factor 9/80 or 11%, which is significant.

Some issues:

- RF voltage corresponding to 11% extra energy loss per turn may be sufficient (5.45 MeV to 6.6 MeV). Beam loading at 100 mA would be equivalent to operating at 122 mA, doable.
- How to handle the extra power that is the equivalent of 9 dipoles in one small fan. (545 kW * 0.22 = 120 kW)
- Determine minimum period length required to prevent significant quantum excitation. Period length also determines size of fan.
- Nonlinear terms from wiggler.